SCREENING FRESHMEN COMPUTER SCIENCE MAJORS

Emery Gathers
Department of Mathematics and
Computer Science
The University of Tennessee at Martin
Martin, TN 32838-5049

Abstract

Ten factors were studied to determine their relationship to success in the first computer science course (Programming Concepts and Problem Solving) for majors. The ten factors studied were the following: high school grade point average, ACT scores (English, math, social science, natural science, and composite), Nelson Denny Reading scores (vocabulary, comprehension, and total grade equivalent), and the UTM Math Placement Test score. Of these placement factors, only the ACT English score and the UTM math placement test were significant in reducing the failure rate in the first course in computer science for majors. The ACT English score was the single best predictor of success.

Introduction

The rapid increase in the need for computer science personnel in our society is attracting many individuals wanting education in computer science who do not have the maturity to succeed in computer science. The increase in the number of such students is already being observed by many schools, resulting in the use of relatively scarce faculty resources in an attempt to educate individuals who will not successfully complete a technical course, while keeping out students who might succeed if permitted to enroll.

How does a faculty advisor determine whether or not a prospective computer science major will succeed in the first course for a computer science major? Many institutions place their prospective computer science majors in a course for beginning computer science majors and these students sink or swim. Other institutions place their students in assorted service courses and/or general education courses which act as screening courses for computer science majors. An advisor should place prospective computer science majors in the first course for computer science majors based upon their probability of success. Those students who score below a certain level on known variables that indicate success in computer science should only be permitted to enroll for a nontechnical "computer survey" course involving a minimal amount of BASIC programming. Based on the students' success in this course and their continued interest in computer science, they may be allowed to continue in the computer science curriculum. This procedure will allow students with a high potential for success to have a better opportunity to enroll in the first programming concepts and problem solving course, and will allow those with less potential for success to gain more exposure to computer concepts and receive a better assessment of their skills before attempting more rigorous courses. Previous researchers have attempted to predict performance in introductory programming courses [3, 5, 8, 9, 10], service courses for assorted majors [6, 8, 14], and introductory computing courses for business majors [1, 11]. Campbell and McCabe [4] indicated that the SAT math and verbal scores, the high school rank, and the high school background in math and science were the most predictive variables for forecasting success of computer science, engineering, or other science majors. More than 1700 institutions of higher education in all fifty states and the District of Columbia participate in the ACT college entrance examination program [2]. The Nelson Denny Reading test is a nationally available reading test. However, none of the previous studies included standardized reading scores (such as Nelson Denny Reading scores) and the ACT scores (math, English, natural science, and social science) in predicting the success of the college freshman computer science major in his first computing course. This study is concerned with the identification and use of such available factors which could successfully predict the success of freshmen computer science majors in their first computer course.

Population

The University of Tennessee at Martin has an enrollment of 5000 students with

256 computer science majors. Every student is required to submit ACT scores for admission. During freshman orientation students are required to take the Nelson Denny Reading Examination and The University of Tennessee at Martin (UTM) Mathematics Placement Test [7]. The UTM Math Placement Test has a Kuder-Richardson Formula 20 coefficient of 0.81 and a multiple correlation coefficient of 0.75 between the UTM Math Placement Test score and a combination of the first quarter math grade and the ACT math score [7]. The first quarter freshman computer science major enrolls in calculus (4 hrs.), Programming Concepts and Problem Solving (3 hrs.), a laboratory science (4 hrs.), English (3 hrs.), and a humanities course (3 hrs.). The first computer science course concentrates on writing algorithms, with PASCAL being introduced the last half of the course [13].

Two populations were used in this study. The first population consisted of 87 freshman computer science majors (53 men and 34 women) enrolled in and having completed, during the Fall quarters of 1982 and 1983, their first course in computer science. This population consisted of 63 students (ABC group) with a final grade of C or better and 24 students with a final grade of D or F (DF group). A second population consisted of 44 freshmen computer science majors (27 men and 17 women) from the Fall quarter 1984.

Method

Ten factors were studied to determine their relationship to success in the first computer science course (Programming Concepts and Problem Solving) for majors. Success was measured as a final grade of C or better in this course. The ten factors studied were the following: high school grade point average, ACT scores (English, math, social science, natural science, and composite), Nelson Denny Reading scores (vocabulary, comprehension, and total grade equivalent), and UTM Math Placement Test score. Stepwise discriminate analysis was used to determine which ten factors were significant in separating the Fall 82 and 83 ABC and DF groups. A factor was significant if it satisfied all the following criteria in the stepwise discriminate analysis: 1) the F test for the canonical discriminate function was at the .001 level of significance, 2) each factor's Univariate F-ratio was at the .05 level of significance, and 3) each factor's stepwise F ratio was at the .001 level of significance (Tables I and II). Using the significant factors, a discriminate function was derived and cutting scores were formulated for the Fall 82 and 83 ABC group (Table III). These cutting scores were ACT English > 17 or 0.78 (ACT English) + 0.49 (UTM math score) > 33. Note in Table II that the discriminate coefficient for the Nelson Denny Vocabulary Grade Equivalent score was -0.62. This indicates that more unsuccessful students in the first programming concepts and problem solving course have a higher vocabulary level than the successful students. The Fall 84 Population was placed in this first course of computer science in the Fall of 1984 using the cutting scores derived from the population 82 and 83 (Table IV). The discriminate function used in placing population 84 had an F test ratio that was significant at the one percent level (Table IV). Hence each discriminator did have some ability to discriminate between the Fall 84 ABC and DF groups in the first computer science course for majors.

Findings and Conclusions

The significant factors in the successful placement of college freshman computer science majors in their first computer course for majors were the ACT English and UTM Math Placement Test scores. Cutting scores consisting of the ACT English score or a combination of the ACT English score and UTM Math Placement Test score were used to place the 44 Fall, 1984, computer science freshmen in their first computer science course. These cutting scores reduced the freshman failures in this course from 28% in the Falls of 82 and 83 to 18% in the Fall of 84. The ACT English score was the single best predictor of success for computer science majors in their first computer course. The ACT English score with a combination of ACT English and UTM math placement scores was the overall best predictor of success. Campbell and McCabe [4] found SAT math and verbal scores to be predictors of success in computer science, but did not indicate which score was a better predictor. Nor did they list SAT math and verbal scores as a possible combination score to be used for predicting success in computer science.

The ACT scores (math, social science, natural science, and composite), the Nelson Denny Reading scores (vocabulary, comprehension, and total grade equivalent), and the high school grade point average were not significant in the placement of freshman computer science majors in their first course in computer science. That is, these scores would not be reliable predictors of success in the first computer courses for computing majors, nor would they add appreciably to the refinement of a combination of cutting scores to predict student success in this course.

It is interesting that ACT English scores were reliable predictors, but reading scores including vocabulary, comprehension, and reading rate were not reliable predictors. This research

indicated that verbal skills are just as important or maybe more so than mathematical skills in predicting success of computer science majors in their first computer course. The verbal skills of listening, writing, sentence structure, and grammar need to be investigated as predictors of success in computer science. In particular, further research is needed to discover to what degree the basic elements of writing such as punctuation, capitalization, phraseology, style and organization predict success in computer science. Do different English and verbal skills predict success in different areas within computer science? This research indicated that the best predictor of success in the first course for computer science majors is a combination of English and mathematical skills. What type of skills in English and mathematics would best predict success in computer science? The SAT math test involves questions in the areas of arithmetic, algebra, and geometry, and require the student to understand elementary mathematics, apply mathematical knowledge to new situations, and apply graphic, spatial, numerical, and symbolic techniques to related areas, such as economics. The UTM math placement test consists of questions in arithmetic, algebra, and trigonometry. The student is required to understand the elementary concepts in each area in a spiral fashion. Further research is needed to determine which of these mathematical skills, along with the writing, listening, sentence structure, and grammar would predict success in computer science.

Even though further research is necessary, there exists, for institutions requiring ACT admission scores, an available placement technique for placing computer science majors in their first computer course. This technique is described as follows:

a) Use the last fall semester enrollment in your first course required for computer science majors. Find the mean of the ACT English score for both the ABC and DF groups of these fall classes.

b) Your cutting score or placement score is

(ACT English ABC mean + ACT English DF mean)/2.

Refine these ACT English cutting scores again next fall. For those prospective computer science majors who have an ACT English score below the derived cutting score, place them in a "computer survey" course. This technique will not only reduce your failure rate in the first computer course for computer science majors, but will help prevent computer anxiety in the students who would have failed this first course, and provided more opportunities for enrollment in the first course for majors who will succeed.

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Table I

Means and Common Standard Deviations for Fall 82 and 83 ABC and DF GROUPS on Significant Placement Variables in the Analysis After Step 4.

Variables	ABC	DF	Common Standard Deviation (1)
ACT English Score	21	17	4.4
UTM Math Placement Test Score	53	44	13.5
Nelson Denny Vocabulary Grade Equivalent	14.2	13.7	2.2
ACT Natural Science Score	25	21	3.2

(1) The squares of these values are the within-group means of squares (the error terms for univariate analysis).

Table II

Test Statistics for Comparison Between Fall 82 and 83 ABC and DF GROUPS on Computer Science Placement Variables

Placement Variables(1)	Univariate F(2) (df=1,85)	p	Stepwise F(2)	p	Standardized Discriminant Coefficient(3)
ACT English Score	15.85	***	10.28	***	0.83
UTM Math Placement Test	8.63	*	3.01	***	0.41
Nelson Denny Vocabulary Grade Equivalent	0.91		4.21	***	-0.62
ACT Natural Science Score	8.26		1.84	**	0.40

Multivariate F = 6.33 (df = 4.82) X = 22.5 (df = 4) p < .001

(1) Computer science variables in the analysis after step 4 Variables are listed in the order in which the stepwise analysis was performed. Thus, Stepwise F shows the significance of the indicated dependent variable, controlling for all variables listed above it.
(2) * P < .05, ** P < .01, *** P < .001.
(3) The sign of the discriminant function coefficients shows the direction of relationship. A positive sign indicates that ABC GROUP students were higher on the dependent variable than DF GROUP students.

Table III

Cutting Scores
ACT English > 17 or 0.78 (ACT English) + 0.49 (UTM Math) > 33

Predicted Group 82 and 83 Membership

	ABC	DF
Number Cases		
63 ABC	61	2
	98.6%	3.2%
24 DF	14	10
	58.3%	41.7%

Percent of grouped cases correctly classified: 81.6%.

Table IV

Failure Rate Comparison

	Population Fall 82 and 83				Population Fall 84			
	ABC	DF	Total	% of DF	ABC	DF	Total	% of DF
No. Students	63	24	87	28	36	8	44	18
Means								
ACT English	21	17	20		21	18	20	
UTM Math	53	44	51		53	43	52	

Discriminate Function
0.78 (ACT English) + 0.49 (UTM MAth) > 33
or ACT English > 17

Population Fall 84
F ratio = 534 df = (2.41)
p <.01 ▲

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INTRODUCTION TO COMPUTER USE--continued from page 43

First Course

- Use of Software Packages
+
- main components of a computer system
- history of computers
- elementary computer operations
- input/output methods and devices
- auxiliary storage and file processing
- microcomputers and their uses
- social impact of computers

Second Course

- Introduction to programming in BASIC
+
- algorithm and program design
- overview of programming languages
- introduction to operating systems
- microcomputers and their uses
- data communications
- social impact of computers

The Department is currently considering dividing this course into two half courses as described above.

As follow-up to Introduction to Computer Use, the Service Program offers a number of half-year courses: Information and the Organization, Information and the Individual, and Logic Programming. However, due to heavy demands on the Department's resources, these courses are not offered on a regular basis at the present time.

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